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# SINEW Mask: An Improved Design to Purify Air We Breathe

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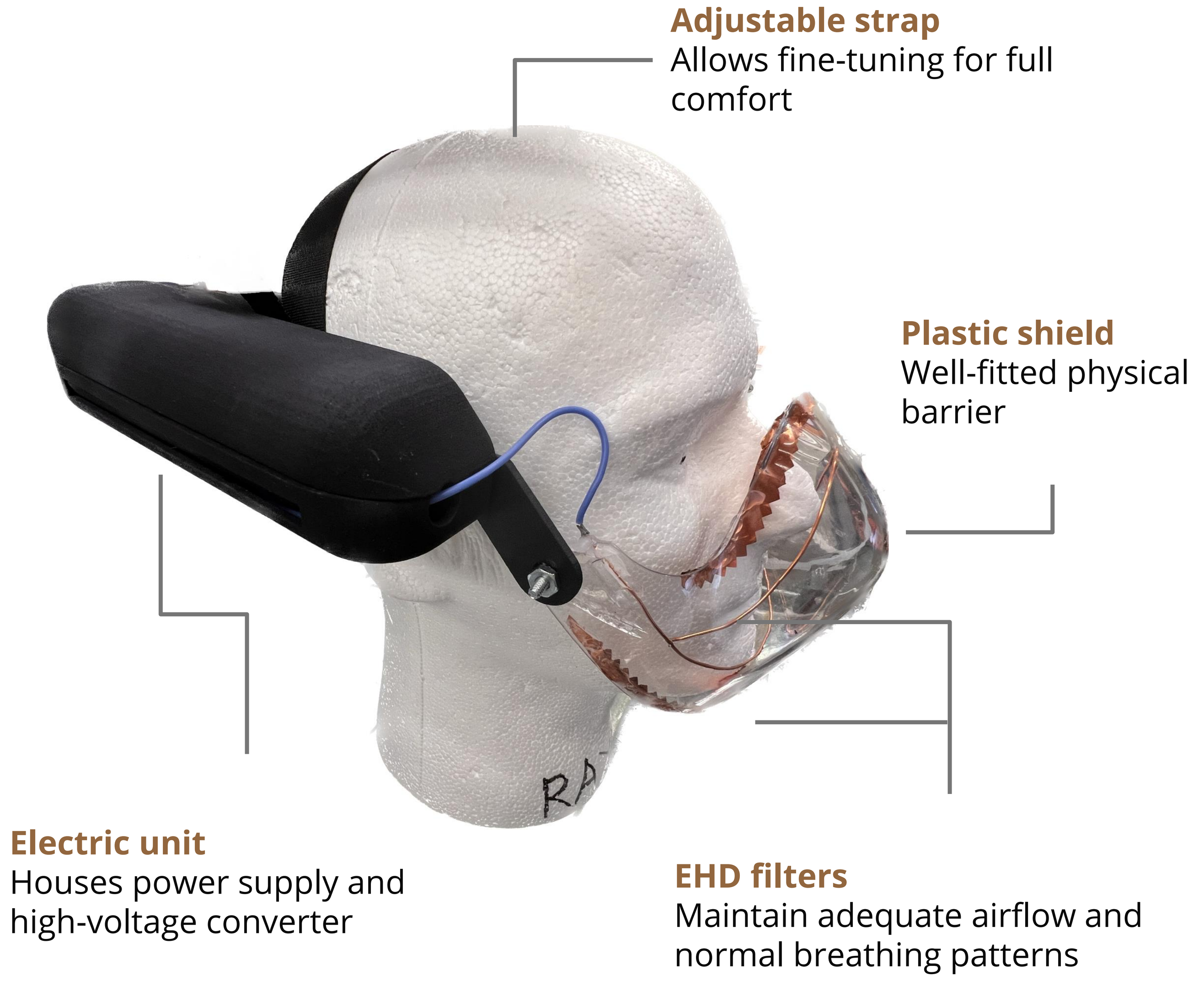
## Background

Air-purifying respirators protect against occupational exposure to volatile organic compounds (VOCs) in the air. Nonetheless, respirators currently in the market lack sufficient long-term filtration capabilities, degrade into microplastics which pollute the environment, and cause bruising after prolonged wear. Our solution, dubbed the **Smart, Individualized, Noncontact, Extended-Wear (SINEW) Mask**, handles these common issues with its ergonomeric design and use of efficient electrohydrodynamic (EHD) based filtration.

## Innovation

The SINEW Mask consists of a flexible headband, compact, high-voltage power supply, and two electrodes utilizing DC corona discharge. With 2-year lifespan, this product is 10% the cost of purchasing the comparative amount of N95 masks over its lifetime. It **can filter VOCs without touching the wearer's face**. Mask features are labeled below:




Non-thermal plasma created through dielectric barrier discharge (DBD) can also remove VOCs through ionization of particulate matter and ionic wind resulting from the EHD force of DBD.

This concept has been proven by Tanski et al., who utilized a two-stage electrostatic precipitator (ESP) with a surface DBD ionizer and two collecting electrodes to achieve a maximum filtration efficiency, flow rate, and average velocity of 89%, 28 l/min, and 2.4 m/s given an applied voltage of 14 kV and 3 mm flow guide gap width.

## Results

### Power Electronics

- **Custom power supply** capable of pulses up to **20 kV**, 40 kHz, 10 W
- Power-weight ratio of 4 kg/kW, weight of 40 g, footprint of L: W: H = 20 mm: 61 mm: 24 mm

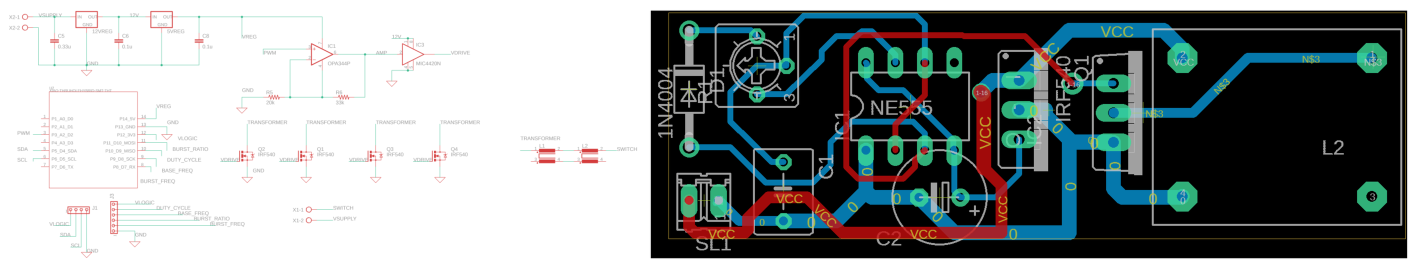


**Figure 1.** Schematic and board of DC corona discharge power supply.

### Mask Integration and Testing

- **Acrylic testing chamber** with vacuum pump, nebulizer, and 0.5% NaCl solution eliminates influence of external air movement
- Filtration efficiency calculated with particle counter (Met One, Model A2408, sensor range 0.5 – 5 μm at 1 CFM) and sampling time of 30 sec
- Achieves up to 70% filtration efficiency of 0.5 μm particles with DC corona discharge

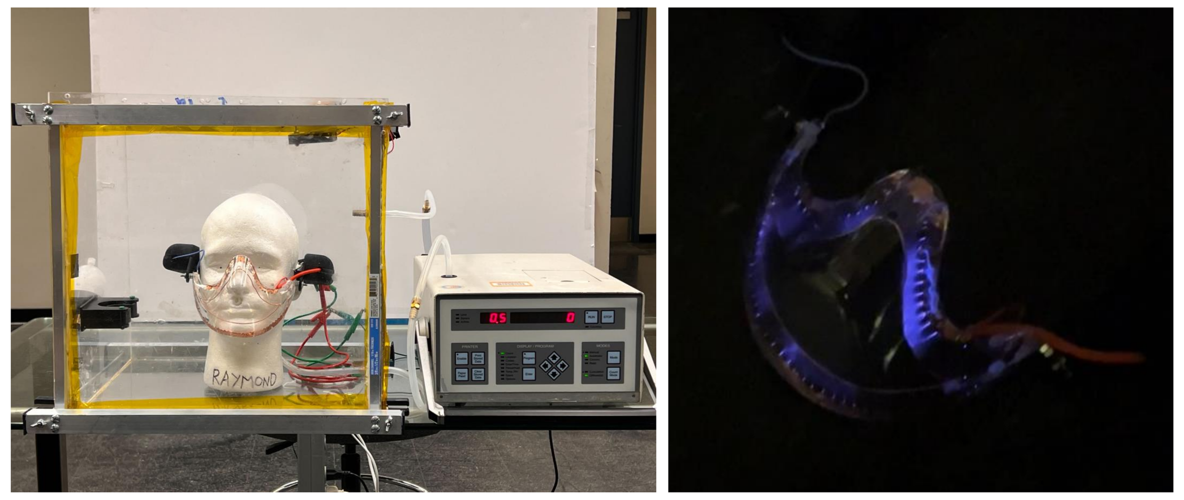


**Figure 2.** (Left) Acrylic testing chamber with SINEW Mask and particle counter. (Right) Visible plasma on mask from DC corona discharge.

### Mechanical Design

- **SLS 3D printed** mask frame attached to plastic, transparent mask
- **DC corona discharge electrodes** placed on inner side of mask, with mask shield placed to protect user from plasma
- **Cutouts** for heat dissipation plate, **snap mechanism** for easier assembly of electronics

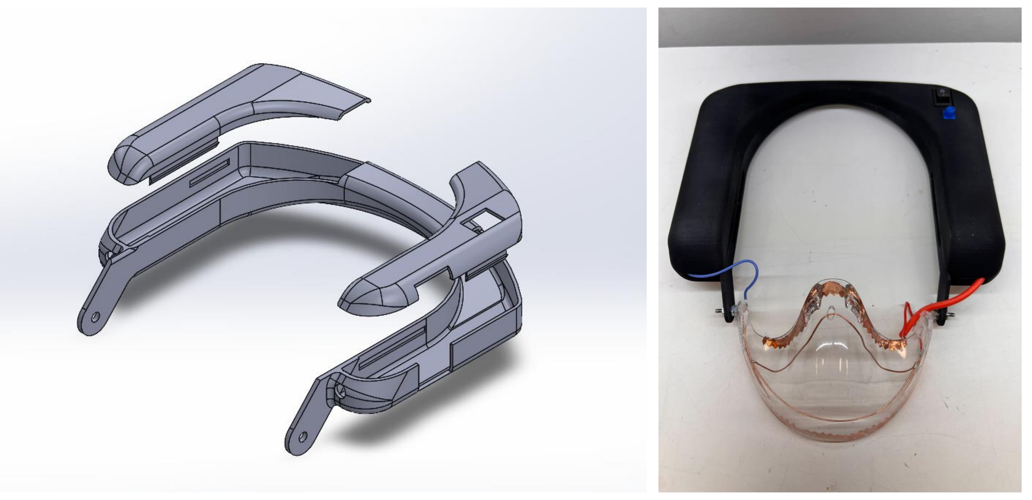


**Figure 3.** (Left) Exploded view of mask frame.
(Right) Completed SINEW Mask with full-perimeter electrodes and SLS 3D printed mask frame.

## Project Progress

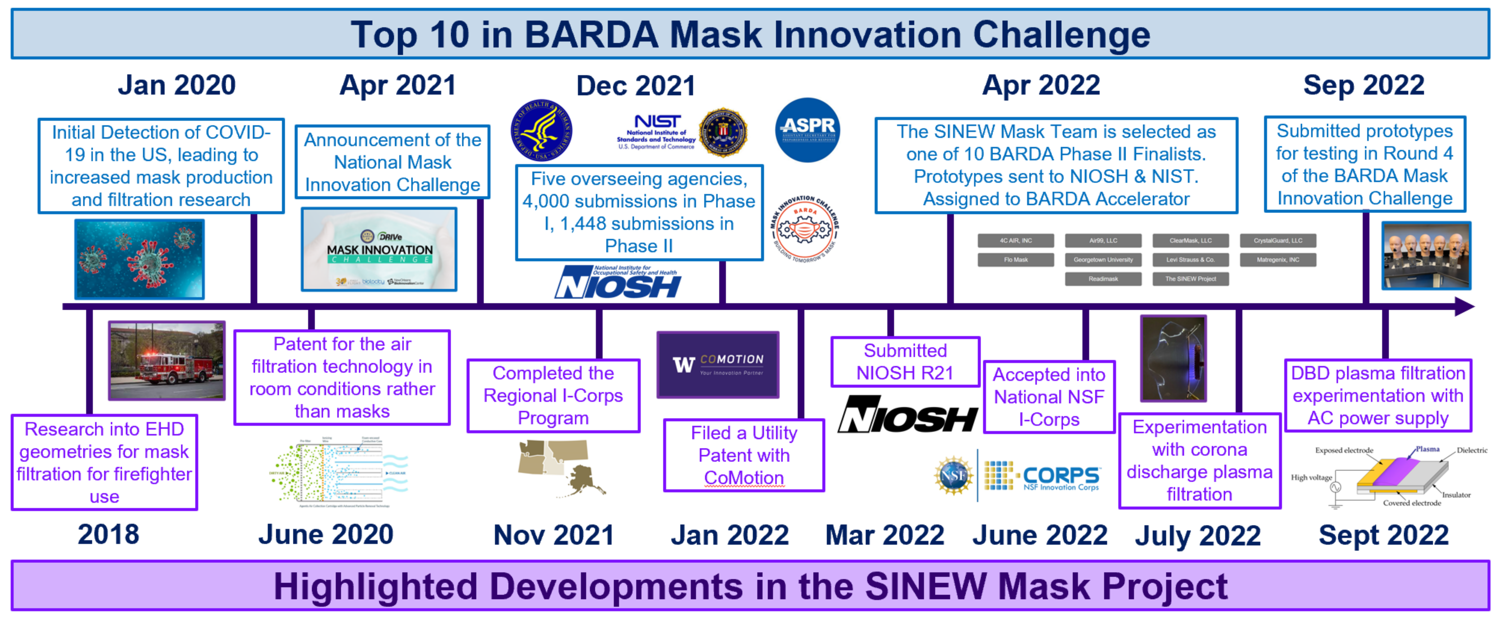



**Figure 4.** Timeline of the team's recent success. (Top) Over of the team's performance during Phase II of the BARDA Innovation Mask Challenge, wherein the SINEW Mask team outcompeted thousands of novel mask designs and placed in top 10 finalists.

## Conclusions

### Project Milestones

- Development of DC corona discharge air purifying respirator (APR) with 70% filtration efficiency, maximum weight of 250 g, and fit factor of 20
- Filtration efficiency characterization over particle sizes 0.5 – 5 μm and operating voltage of 20 kV
- Design of microcontroller-based power supply to support the development of remotely operated SINEW Mask

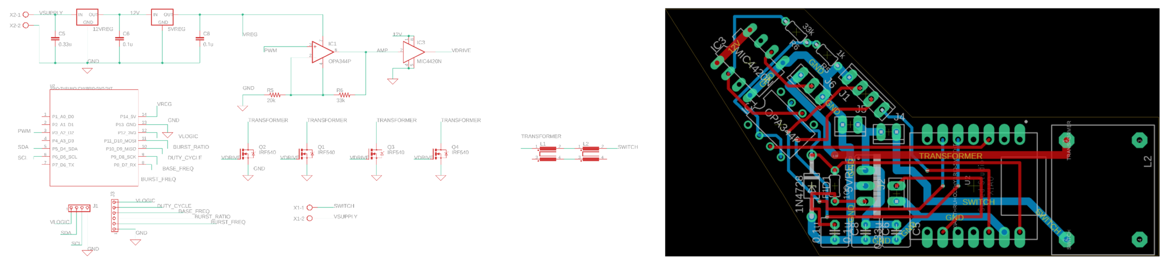


**Figure 5.** Schematic and board of DBD power supply.

### Next Steps

- **Integration** of **dielectric barrier discharge (DBD)** electrodes onto inner side of mask
- **Exploration** of additional DBD electrode configurations including point-planar geometries
- **Reduction** and **characterization** of ozone concentration to below 10 ppb

**Figure 6.** Visible plasma formed along 1/8" acrylic surface.